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Turbine Technologies: Ceramic Turbine Engine Demonstration Project

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Abstract

Under the U.S. Dept. of Energy (DoE) funded Ceramic Turbine Engine Demonstration Project (CTEDP), AlliedSignal Engines is addressing remaining critical concerns slowing the commercialization of structural ceramics in gas turbine engines. These issues include demonstration of ceramic component reliability, readiness of ceramic suppliers to support ceramic production needs, and development of ceramic design technologies.

The AlliedSignal/Garrett Model 331-200[CT] auxiliary power unit (APU) is being used as a ceramics test bed engine. The first-stage turbine blades and nozzles were redesigned for ceramic materials, employing design methods developed during the earlier Dept. of Energy/National Aeronautics and Space Administration (DoE/NASA)-funded Advanced Gas Turbine (AGT) and Advanced Turbine Technology Applications (ATTAP) programs. The fabrication processes for these components provide the framework for demonstration of ceramic manufacturing process scale-up to the minimum level for commercial viability. Ceramic engine components have been fabricated and are now being evaluated in laboratory engine testing. This testing is helping to refine the component designs and focus the development of ceramic component technologies. Extended engine endurance testing and field testing in commercial aircraft is planned, to demonstrate ceramic component reliability.

Significant progress was made during 1996 in the ceramic component manufacturing scale-up activities. The CTEDP ceramics subcontractors, AlliedSignal Ceramic Components (Torrance, CA) and Kyocera Industrial Ceramics Corporation (Vancouver, WA) demonstrated increased capacity and improved yields of silicon nitride materials. Planned ceramic turbine nozzle manufacturing demonstrations were initiated by both companies.

Ceramic design technology was further refined in several areas. Contact rig tests and supporting analyses helped define the effectiveness of compliant layers in reducing contact stresses, and the results are aiding the evolution of more effective compliant layer configurations. This work supported the evaluation of various ceramic turbine blade attachment designs in subelement and engine tests. Thin-film strain gage technology for measuring vibratory levels at high temperatures was successfully demonstrated on ceramic turbine blades. Ceramic materials were screened for susceptibility to cyclic fatigue at the conditions affecting ceramic turbine blades. Work also continued in defining impact modeling boundary conditions for ceramic turbine engines, and this effort included a 3-D trajectory analysis of combustor carbon particles in the engine gas flowpath.

Over 470 additional hours of successful operation were accumulated in engine endurance tests with ceramic turbine nozzles. Ceramic turbine blades were also successfully demonstrated in over 135 hours of engine operation. This work brought the combined ceramic component engine test experience to over 1500 hours.

Work summarized in this poster presentation was funded by the U.S. Dept. of Energy (DoE) Office of Transportation Technologies, as part of the Turbine Engine Technologies Program, and administered through Fiscal Year 1996 by the NASA Lewis Research Center, Cleveland, OH under Contract No. DEN3-335.